The Ecology of Sex Part 2: The Ecology of Sex

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Biol 417: Evolutionary Ecology

Table of contents

Review

Review

Last lecture we covered the costs & benefits of sexual reproduction.

Costs of sex

- Half of genes passed on
- Slow
- Dangerous
- Wasteful
- Unpredictable
- Requires a compatible mate
- Breaks up linkages
- Small pops. are prone to extinction

Benefits of sex

- Increases variability
- Prevents buildup of deleterious mutations

Review cont.

Sexual reproduction is extremely costly and the main benefits are that sex increases genetic variability and prevents buildup of deleterious mutations.

Because sexual reproduction is so costly, and variance is the primary benefit, we found ourselves asking how it became so prevalent across the kingdom of life?

I told you that the ecological context of sexual reproduction is everything.

Today we will cover how environmental conditions can tip the balance in favour of sexual reproduction.

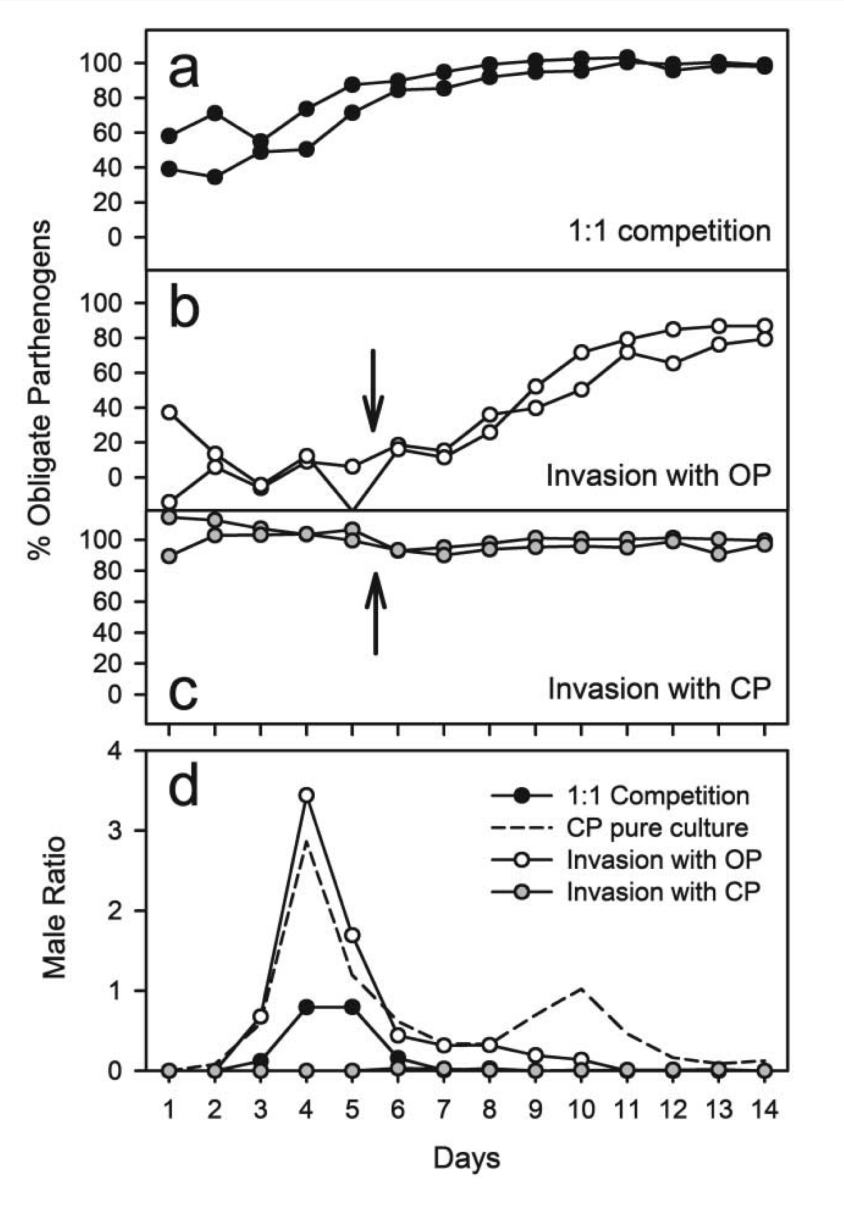
The Ecology of Sex

Reproduction in B. calyciflorus

The rotifer *Brachionus calyciflorus* can reproduce either sexually or asexually.

Unfertilised oocytes turn directly into adults, fertilised oocytes turn into diapausing eggs, then mature.

Reproduction in B. calyciflorus



Over short timescales, asexuals outcompete sexuals because diapausing eggs and male/female phenotypes slow population growth (Stelzer, 2011).

Reproduction in B. calyciflorus

If asexual reproduction wins out over short timescales, should sex persist in the population?

How would these two strategies fare during a period of unfavourable conditions?

Asexual lineages would die out during a prolonged period of habitat deterioration and only diapausing eggs would survive.

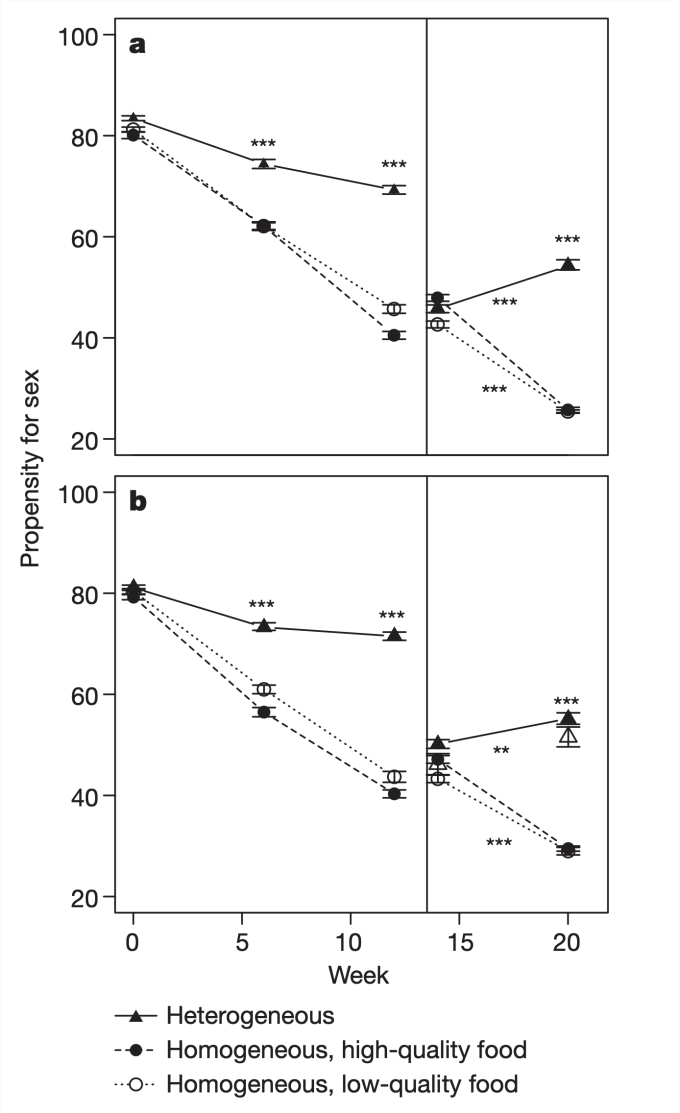
... in other words sex buffers against habitat stochasticity.

Reproduction in B. calyciflorus

Becks & Agrawal (2010) reared 30 populations of *B. calyciflorus* for 20 weeks under high-food homogenous, low-food homogenous, and heterogeneous conditions.

Note: average generation time of *B. calyciflorus* is around 2.2 days at 24 °C.

Reproduction in B. calyciflorus



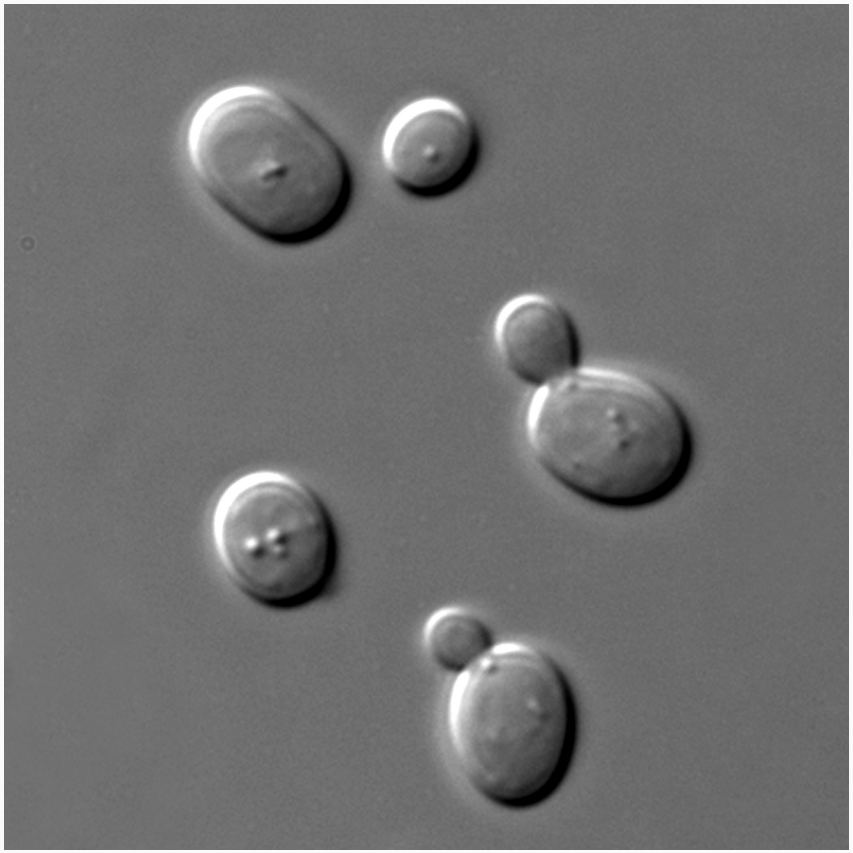
In homogeneous environments, with all good- or all bad-quality food, asexual reproduction is favoured (Becks & Agrawal, 2010).

In heterogeneous environments with mixed food sources resulted in sexually reproducing populations (Becks & Agrawal, 2010).

... i.e., sex allows for adaptations in heterogeneous environments.

Tangled Bank Hypothesis

Reproduction in yeast



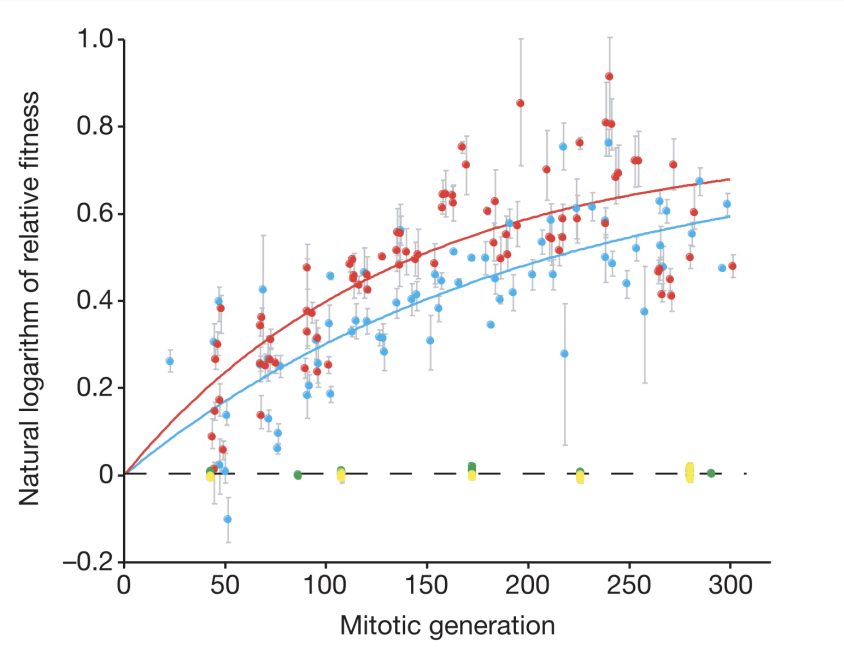
Source: Wikipedia

Yeast can reproduce asexually via either budding or fission, or can undergo meiosis and form haploid spores that eventually fuse with other spores to form a diploid zygote.

Goddard *et al.* (2005) placed strains of sexually or asexually reproducing yeast into both favourable and harsh conditions.

Expectation?

Reproduction in yeast



Goddard *et al.* (2005)

In the favourable environment there was no difference in fitness between the two populations (no benefit to sex).

In the harsh environment, sexual populations adapted more rapidly and survived better than the asexuals.

... in other words sex speeds up the pace of natural selection.

Ecology of sex

These studies suggest that in stable, productive environments the costs of sex outweigh the benefits.

Source: Adrian Chesterman — Photowall

Ecology of sex cont.

Bell (1982) reviewed the distribution of sex in the Metazoa.

Around the same time, Bierzychudek (1985) reviewed the distribution of sex in plants.

Expectation?

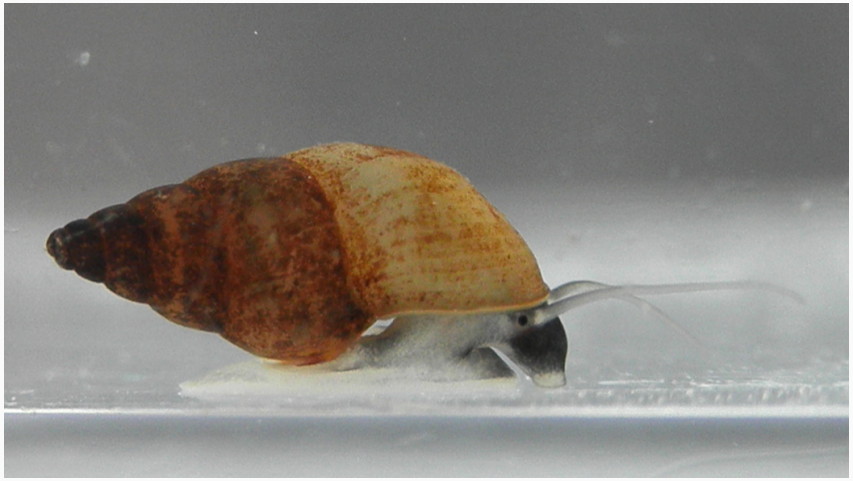
Bell (1982) and Bierzychudek (1985) found that there is a consistent trend for sex to be more common in stable productive environments.

Asexual reproduction occurs more often at extreme latitudes and altitudes and in early succession.

Reproduction in B. calyciflorus

At low densities *B. calyciflorus* reproduces asexually, but in crowded environments, the rotifers release a chemical cue that induces sexual reproduction.

Mud snail reproduction



Source: Wikipedia

The mud snail *Potamopyrgus antipodarum* exhibits both sexual and asexual reproduction.

They are infected by parasites which specialise on the most common genotypes.

Soper *et al.* (2014) showed that exposing populations to parasites increased the rate of sexual reproduction.

... i.e., sex allows for heterogeneous offspring that are less susceptible to infection.

Red Queen Hypothesis

Parasites in rotifers

Sex allows for heterogeneous offspring that are less susceptible to infection... but it's not the only mechanism for avoiding infection.

When asexual bdelloid rotifers are exposed to a fungal parasite, they desiccate and then a light breeze can blow them away to a new environment where they can grow infection free (Wilson, 2011).

... i.e., sex is not essential for parasitic avoidance.

Genetic variance in rotifers

Desiccation compromise cellular integrity, which results in the absorption of DNA from other sources like bacteria, fungi, and other nearby organisms.

In bdelloids, ca. 7 to 10 percent of the genes are of nonmetazoan origin, and most of the foreign genes are expressed (Boschetti *et al.*, 2012).

... i.e., meiosis and sex are not essential for genetic exchange.

Take homes

In a homogenous, static world, sex is likely unnecessary.

In stochastic, heterogeneous environments, sex allows species to respond to change more rapidly.

Sex also allows gives species an edge in competitive environments where niche space is limited (i.e., a mutation that expands niche space can allow species to win out over competitors).

... but there are mechanisms other than sex for overcoming environmental change, competition, and parasitism, that avoid the high cost of sex.

The prevalence of sex is still largely an evolutionary paradox.

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